Soil Evaluator Course
Chapter Two

SOIL PROFILE DESCRIPTIONS

SOIL HORIZON AND LAYER DESIGNATIONS (SUMMARY)

ORGANIC HORIZONS

O-HORIZON or LAYER: Layers dominated by organic material.

Field Criteria:
- 20-30% organic matter.
- dark color (never used by itself).
- low strength, low dry weight, high fiber content.
- typically a surface horizon - if buried may indicate disturbance.

HORIZONS AND LAYERS IN MINERAL SOILS

A-HORIZON: Generally referred to as topsoil and typically ranging from 3 to 10 inches thick. Mineral horizon formed at the surface or below an 0-horizon. Characterized by an accumulation of humified organic matter intimately mixed with the mineral fraction.

Field Criteria:
- mineral soil material.
- mix of well-decomposed organic matter and mineral material.
- surface mineral horizon.
- typically dark in color, darker than underlying horizons.

Formation: Mixing of organic matter derived from litter decomposition, with mineral soil material resulting in organic coatings of mineral grains as reflected by the dark color of this horizon.

Subordinate Distinctions of A-Horizons: Ap - plowing or other disturbance.

E-HORIZON: Mineral horizon in the upper part of the soil, typically underlying an O or A horizon. Light colored, leached horizon ranging from not being present to 4 inches thick.

Field Criteria:
- zone of eluviation; removal of clays, Fe, Al, and humus
- lighter in color than over- or underlying horizons.
- near surface, below O- or A-horizons and above a B-horizon.

Formation: Weak organic acids strip coatings from sand grains (podzolization) or clay may be leached out (lessivage), resulting in a light colored E-horizon due to the natural color of quartz and feldspar sand grains once the coatings are stripped.

Subordinate Distinctions of E-Horizons:
- E - leaching of clays, Fe, Al, and/or organic matter.
- Eg - stripping of iron or presence of organic coatings due to seasonal wetness in addition to leaching of clays, Fe, Al, and organic matter.

B-HORIZON: Generally referred to as subsoil. The zone of accumulation within the soil. In well-drained soils it has the brightest colors. May extend 2 to 4 feet below the surface.

Field Criteria:

- subsurface horizon formed below an A, E, 0 and above the C-horizon.
- formed as a result of soil forming processes.
- weakest expression is color development.
- illuvial concentration; zone of accumulation.

Formation: Accumulation of illuviated materials (clay, Fe, Al, organic matter) or general evidence of soil formation reflected in brighter soil colors or stronger soil structure.

Subordinate Distinctions of B-Horizons:

- Bt- illuvial accumulation of clay.
- Bh - illuvial accumulation of organic matter (humus).
- Bs- illuvial accumulation of sesquioxides (iron and aluminum).
- Bhs - illuvial accumulation of both organic matter and sesquioxides.
- Bw - development of color or structure.
- Bx - contains a brittle horizon with a relatively high density (fragipan).
- Bg - strong gleying, indicates prolonged periods of saturation.
- Bm - cementation or in duration.

C-LAYER: Generally referred to as substratum. These layers are little affected by soil forming processes (un-weathered geologic material).

Field Criteria:

- little affected by soil formation (little pedological development)
- geologic layering.
- lack of color development, color of un-weathered geologic material.

Subordinate Distinctions of C-Horizons:

Cd - dense unconsolidated sediment, used to designate compact glacial till.
Cg - strong gleying, indicates prolonged periods of saturation.
Cr - weathered or soft bedrock.

R-HORIZON: Hard bedrock.

SOIL HORIZONS AND LAYERS

Soil horizons and/or layers are strata within the soil that typically parallel the ground surface. They may differ from one another by color, feel, texture, presence of rock fragments, etc. There are six major distinctions used to designate horizons and layers in the soil: 0, A, E and B horizons, and C and R layers.

Soil horizons are designated by a combination of:

CAPITAL LETTERS -lower case letters -ARABIC NUMERALS

Master Horizons and Layers: Major breaks in the soil: 0, A, E, B, C, and R.

Subordinate Distinctions: Lower case letters used as suffixes to designate specific master horizons, i.e. Ap, Bw, Cd.

Vertical Subdivisions: A horizon designated by a single combination of letters which needs to be subdivided, i.e. Bwl, Bw2, Cdl, Cd2.

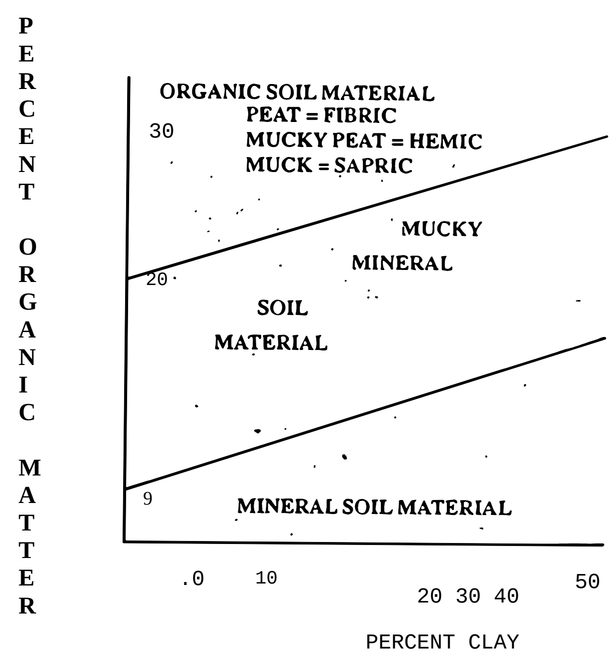
O-HORIZONS are soil layers with a high percentage of organic matter. Typically within a woodland area there are three distinct organic layers: one of leaves, pine needles and twigs (Oi); underlain by a partially decomposed layer (Oe); and then a very dark layer of well decomposed humus (Oa) .

Field Criteria:

- greater than 20-30% organic matter.
- dark, nearly black, color; colors can be misleading and should only be used when other field criteria are observed.
- low strength, greasy feel, light weight when dry, may have a high fiber content.
- typically a very dark surface horizon. When observed buried beneath a mineral horizon, this may signify a disturbed site where the original soil was buried by fill material.

Subordinate Distinctions of O-Horizon:

- **Oa** -highly decomposed organic material (muck).
- **Oe** -moderately decomposed organic material (mucky peat or peaty muck).
- **Oi** -slightly decomposed organic material (peat)



A-HORIZON is commonly referred to as the topsoil and typically ranges from 3 to 10 inches thick. It is a mineral horizon that formed at the surface or below an O-horizon, and is characterized by humified organic matter intimately mixed with the mineral fraction.

Field Criteria:

- a dark, surface, mineral horizon; characteristically darker than underlying horizons due to a relatively high organic matter content.
- mixture of well decomposed organic matter and mineral material.

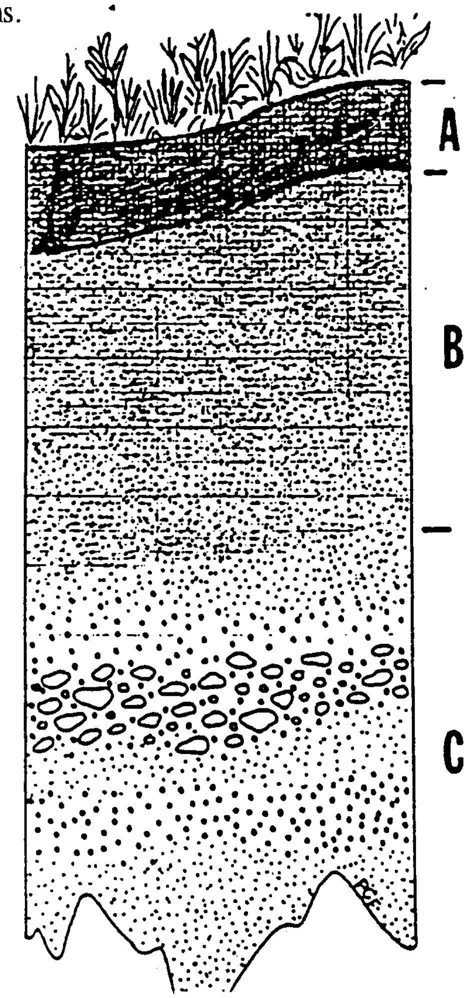
Formation: Accumulation of organic matter under either saturated conditions (e.g. in marshes and bogs), or under aerated conditions where organic matter decomposition of the leaf litter (mineralization) is not an instant process.

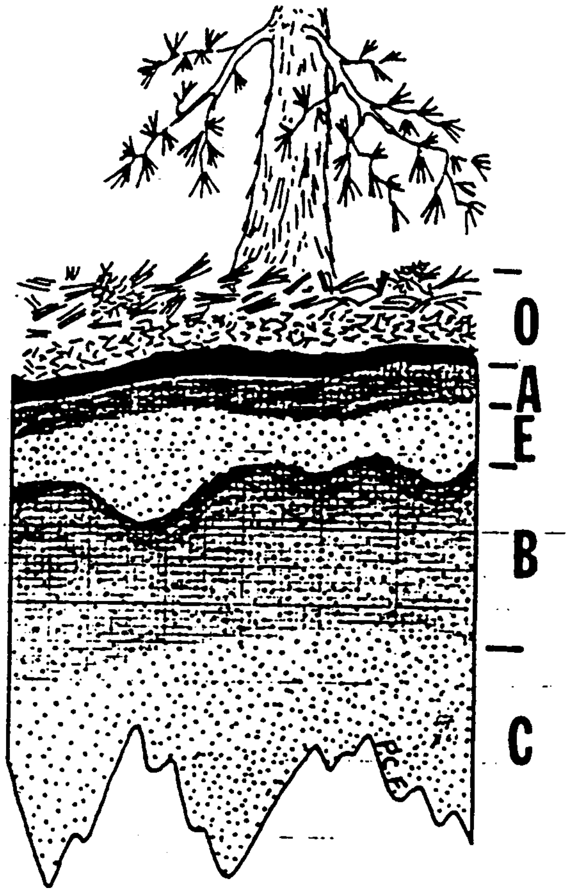
E-HORIZON is a mineral horizon in the upper part of the soil. Typically present only in forested areas it underlies an O- or A-horizon. It is a light colored, leached horizon. E-horizons are uncommon to many areas of Massachusetts and are most prominent within southeastern and northwestern portions of the state**.**

Field Criteria:

• commonly near the surface, underlying an O- or A-horizon and above a B-horizon.
• generally lighter in color than either the overlaying organic and/or A-horizons and the underlying B-horizon.

Formation: weak organic acids strip coating from the sand grains and material is leached down into the subsoil. The light color of the E-horizon is due to the natural color of the dominant quartz sand grains.





B-Horizons are commonly referred to as the subsoil. They are a zone of accumulation where rainwater percolating through the soil has leached material from above and it has precipitated within the B-horizons or the material may have weathered in place. Well-drained soils typically have the brightest color development within the B-horizon.

Field Criteria:
- subsurface horizon formed below an O, A and/or E-horizon and above the C-layer.
- in well-drained soils, the B-horizon is typically a yellowish brown to strong brown color and is commonly referred to as the subsoil.
- within Massachusetts, B-horizons typically extend to a depth of 2 to 3 feet.

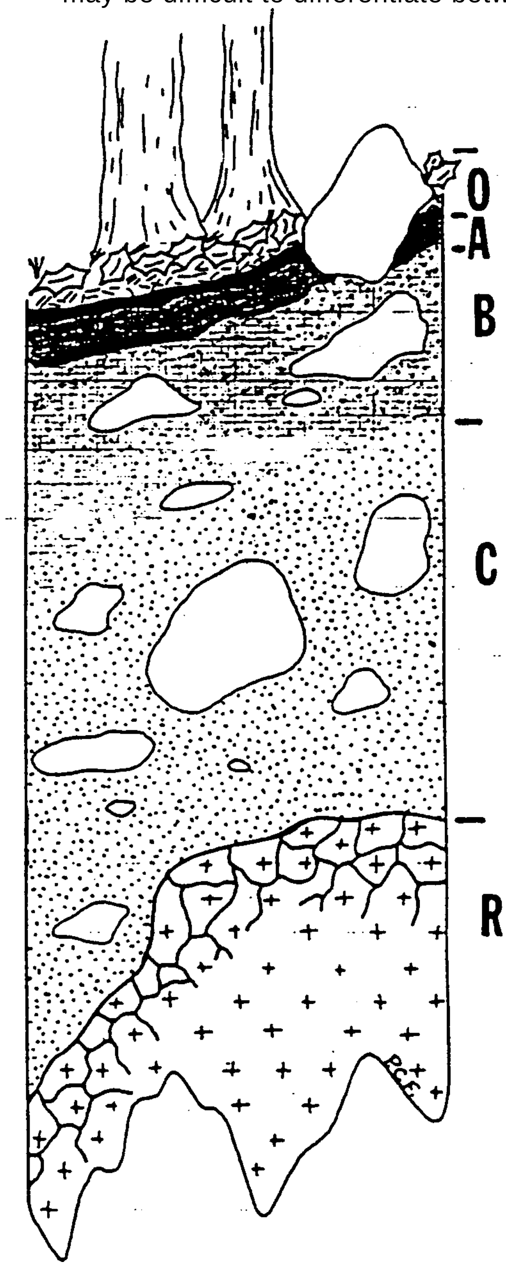
C-Layers are commonly referred to as the substratum. These layers, excluding bedrock, are little affected by soil forming processes and have changed very little if any since the time they were deposited.

Field Criteria:
- little affected by soil forming processes.
- lack color development, color is that of the un-weathered geologic material.
- geologic layering or strata is often present.
- often, but not always, is the geologic material in which the overlaying soil developed.

R-Layers are hard bedrock (ledge).

Field Criteria:

- typically cannot be excavated using a backhoe unless fractured and blasting is often needed to remove this material.
- when highly fractured and/or weathered it is often difficult to differentiate from the overlaying soil material.
- may be difficult to differentiate between large boulders and depth to bedrock.



SOIL TEXTURE

Soil texture refers to the relative proportion of sand, silt, and clay in a soil. There are many different systems describing and classifying soil texture. These systems differ depending on their intended use. There are several standard systems, including USDA, UNIFIED, AASHT0, and FAA. Each breaks the soil up into different size fractions for specific use interpretations. When describing soils, it must be stated which system is being used. For example, "clay" could be soil less than 0.002 mm, 0.005 mm, or gray sticky stuff. For Title 5 purposes, the USDA system will be emphasized since it is the most widely used for describing, classifying and mapping soils; and is applicable to a wide range of uses.

In the USDA system, soil texture refers specifically to the relative proportion of the sand particles (2.0 mm - 0.05 mm), silt particles (0.05 mm - 0.002 mm) and clay particles (smaller than 0.002 mm) in the soil mass.

Sand particles can be seen with the naked eye and have a gritty feel to the fingers. These particles can easily be wiped clean from one's hands leaving no material in the pores of the hand. Dry sand particles are single grained and loose. The sand size particles can be subdivided into the following six classes:

very coarse sand:	2.00 - 1.00 mm
coarse sand:	1.00 - 0.50 mm
medium sand:	0.50 - 0.25 mm
fine sand:	0.25 - 0.10 mm
very fine sand:	0.10 - 0.05 mm

Silt size particles can be seen only with a hand lens or light microscope. They have a smooth powdery feel when dry and a slick creamy feel when moist or wet. Silt is non-sticky and non-plastic. After handling silty soil samples a film will be left on one's hands, which for the most part can be wiped off when dry, leaving silt particles only in the pores of the hand.

Clay size particles can only be seen with an electron microscope. Clay is sticky and plastic when wet, and hard to very hard when dry. After handling clayey samples a film will be left on the hands and only be removed by scrubbing. .

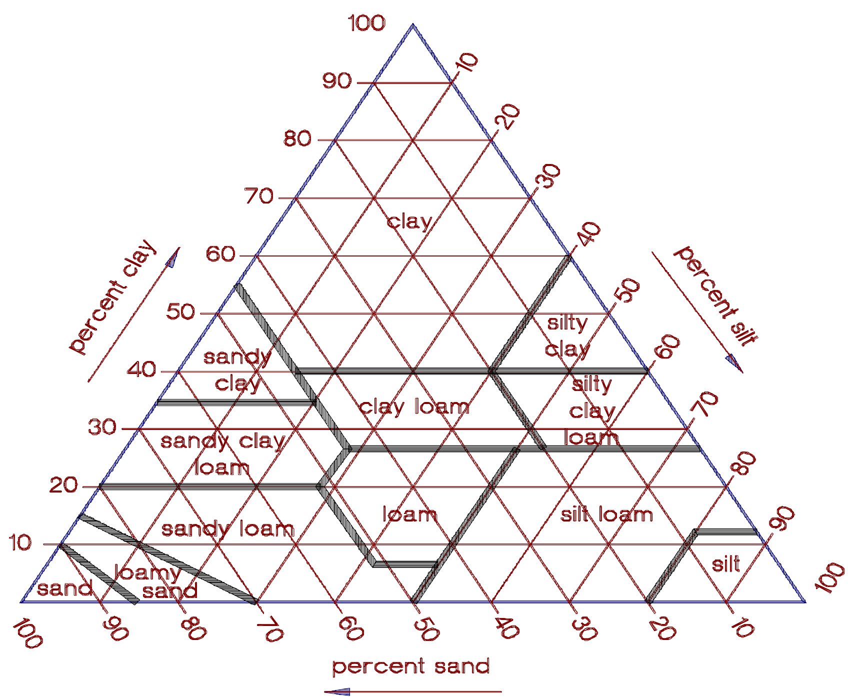
Rock fragments are particles larger than sand size and common in many New England soils. The are classified by their size into:

gravel:	2 mm to 3 inches
cobbles:	3 to 10 inches
stones:	10 inches to 2.5 feet
boulders:	greater than 2.5 feet in diameter

Soil Textural Classes

Rarely in nature do soils consist entirely of one size particle; meaning all sand, all silt or all clay. Generally, soils are a combination or mixture of different particle sizes. Tease different combinations are referred to as textural classes. There are many different textural classes. The basic textural classes usually encountered in Massachusetts in order of increasingly finer texture are: sand, loamy sand, sandy loam, loam, silt loam, silt, silty clay loam, and silty clay. Loam is a term that has many, often, conflicting meanings. The common meaning is that of a dark, fertile topsoil. In the USDA textural classification system loam refers only to the sand, silt and clay size particles; and is a soil with a significant amount of all three particle sizes.

Textural class names provide a basis for making predictions of soil behavior. Although texture is probably the most important single characteristic used to predict soil behavior, other soil properties such as structure and consistence must be considered before an accurate judgment can be made. Soil texture is a primary consideration for predicting hydraulic conductivity, bulk density, water holding capacity, shrink-swell potential, frost action, subsidence, bearing capacity, compactibility, infiltration rate, erodibility, and more.



Textural Triangle

The triangle shows the 12 basic soil textural classes and associated percentages of clay (less than 0.002 mm), silt (0-002 to 0.05 mm), and sand (0.05 to 2.0 mm). The textural triangle is used when laboratory data are available. Plot the percent sand using the bottom of the triangle, silt using the right side, and clay the left. **Caution:** plot percentages following the angle of the numbers on each side of the triangle.

Field Method for Determining Soil Textural Class

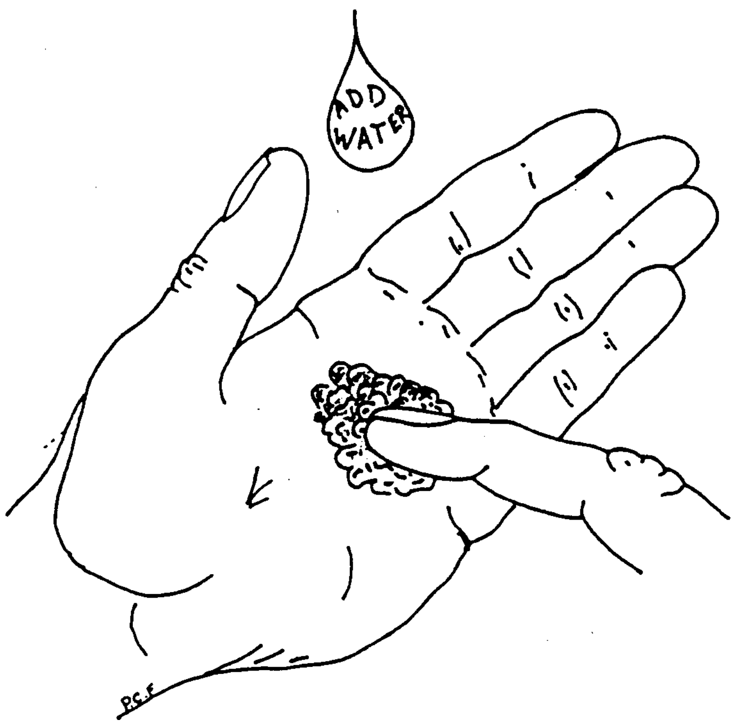
Organic Soils vs. Mineral Soils

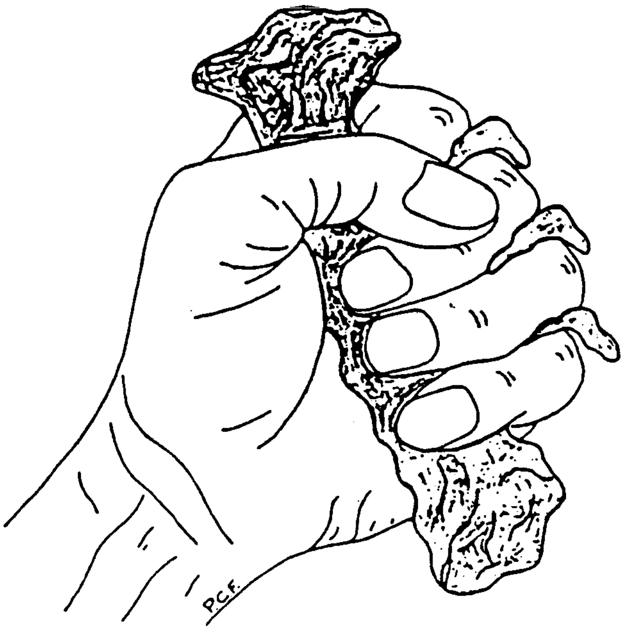
Soils that have a high volume of organic matter (20 to 30%) are classified as organic soils. Depending on the degree of decomposition, organic soils may have many fibers (peat) or have a very greasy, smooth feel (muck).

Field Test:
Place a sample of moist or wet soil material, about the size of a golf ball, in the palm of your hand and squeeze hard. If the sample contains a high percentage of well-decomposed organic matter, it will have a weak strength and ooze through fingers as if it were mashed potatoes. Mineral soil material will not. Also, when dried, organic material is very light whereas mineral material retains most of its weight. A dark soil color indicates the presence of organic matter, but used by itself, will not determine if the soil is mineral or organic.

Sample Preparation:

- place about a tablespoon of representative soil sample in the palm of your hand.





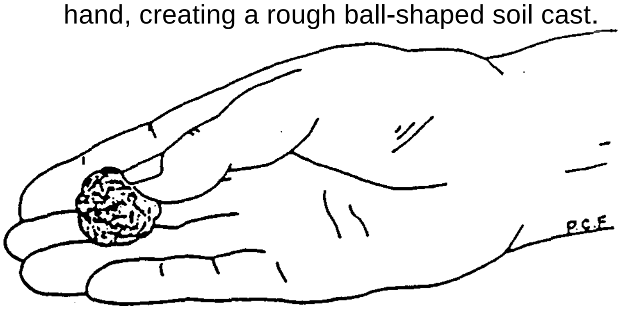
- separate out and remove all particles greater than 2 mm in size, about the diameter of lead in a wooden pencil.
- wet the sample and rub vigorously to break up any aggregates or clods of dry soil.

Soil samples that are comprised predominantly of sand size particles versus soil samples that are predominantly silt and/or clay size particles:

- with the wet soil sample in the palm of your hand, rub and stir with a finger from the opposite hand.
  - soils with more than 50 percent sand size fraction, have a gritty to very gritty feel.
  - soils that have a smooth creamy feel with little to no grittiness, are high in silt and/or clay.

Soils with more than 50 percent sand sized particles:

- Soil textural classes for soils with more than 50 percent sand sized particles include sands, loamy sands, and sandy loams.
- The field test used to differentiate these three textural classes is to make a cast and estimate its durability. To make a cast take a fresh, moist (not too wet nor too dry) sample from the test pit. The moisture condition of the sample is critical when doing this test. A dry sample will not form a cast and a wet sample will almost always form a cast. Place a tablespoon sized sample of moist soil in the palm of your hand and firmly press the sample together with the fingers of the opposite hand, creating a rough ball-shaped soil cast.



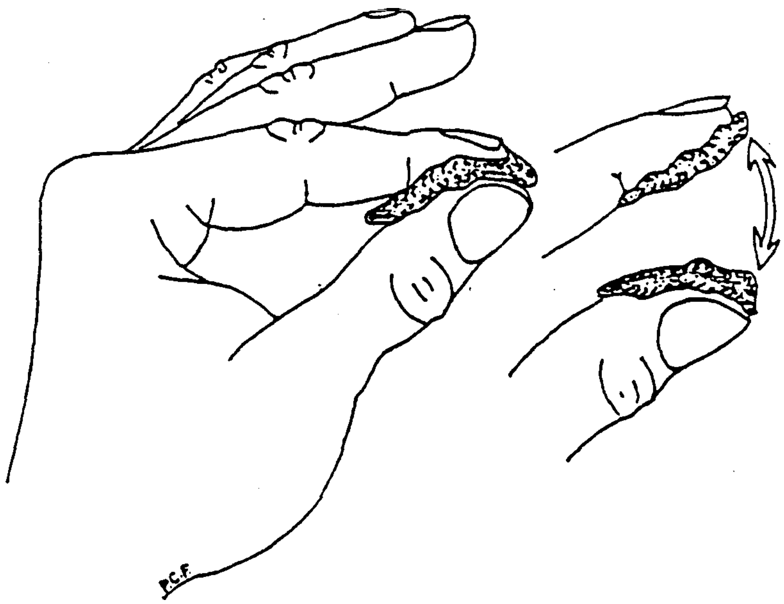
Sand textural class (greater than 85 % sand) will either not form a cast or will form a cast that crumbles with slight handling.

Loamy sand textural class (70 to 85 % sand) will form a cast which bears only slight to moderate handling before falling apart.

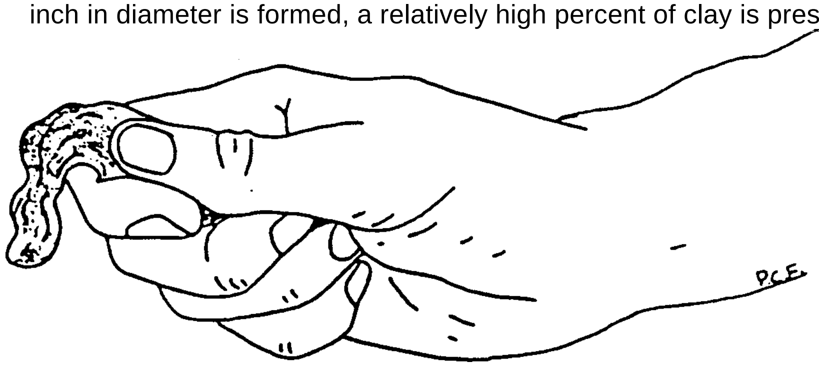
Sandy loam textural class(50 to 70% sand) will form a cast, which will withstand moderate handling and retain its shape.

Soils with more than 50 percent silt and/or clay sized particles:

- The field tests used for differentiating soils that are high in silt from those that have a significant clay content (greater than 30%) are the tests for stickiness and plasticity.
- Moisture content is critical when doing either test. The moisture content that makes the sample the stickiest or most plastic is the one to use. Gradually add moisture to a tablespoon size sample of soil, while mixing in the palm of one's hand.
- **Stickiness test:** squeeze a very moist soil sample between your thumb and index finger and then pull apart. Soil material that is very high in silt is non-sticky and the sample will adhere to either the thumb or finger and separate cleanly from the other. A soil with a significant amount of clay (greater than 30%) will initially stretch between the thumb and finger, and then pull apart with some soil adhering to both the thumb and the finger (silty clay texture).



- **Plasticity test**: There are two procedures for doing this test, forming a ribbon or making a wire. The ribbon test is done by pinching and pushing a thin ribbon of sample out from beneath the thumb and over the top of the index finger. A soil sample high in silt and low in clay will form a short ribbon, typically less than 1.5 inches (silt loam texture). A soil significantly high in clay (more than 30%) will form a ribbon longer than 2 inches (silty clay texture). Another test for plasticity is to form a wire. A soil sample is rolled out into a wire by placing a very moist sample between one's palms and then moving them back and forth over one another. If a wire cracks or breaks before it reaches 1/8 inch in diameter, the sample is high in silt with a small clay fraction (silt loam texture). If a wire less than 1/8 inch in diameter is formed, a relatively high percent of clay is present (silty clay texture).



NOTE: Very fine sandy loam and loam textural classes typically have the feel of both sandy and silty soils. If you are having difficulty deciding on what direction to take above, you may want to consider either of these textural classes. Loam, when dry, can be crushed under moderate pressure and when pulverized has a velvety feel. Loam when moist may have a very slight tendency to ribbon. Very fine sandy loam textures when thoroughly wetted will have a very slightly gritty sensation when rubbed in one's palm.

TEXTURAL CLASS MODIFIERS

Coarse Fragments: If a soil sample has between 15 to 35 percent by volume of coarse fragments (greater than 2 mm in diameter), a textural modifier is used, for example gravelly sandy loam.
If a soil sample has between 35 percent and 60 percent by volume of coarse fragments, a textural modifier is used, for example a very gravelly sandy loam. If the soil sample contains more than 60 percent by volume the modifier is "extremely", e.g. extremely gravelly sandy loam.

Organic Matter: If a soil has a significant volume of organic matter (10 to 20% by weight), a textural modifier is used, for example a mucky sandy loam.

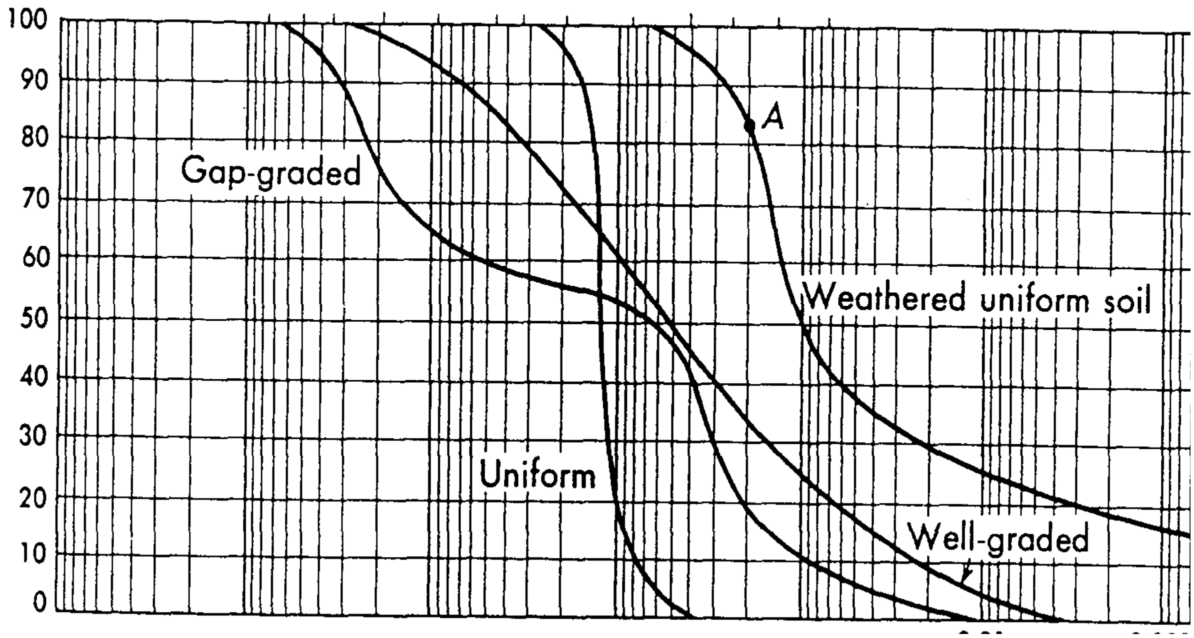
GRADATION CURVES

The results of a mechanical analysis are frequently plotted in the form of a gradation curve. A well-graded soil has a little bit of every grain size, whereas a uniform soil indicates sorting by either wind, water or a sieve to result in a material in which all particles are more or less the same size. Many sand filters and fill materials require a fairly uniform grain size. A sample's uniformity is expressed by the uniformity coefficient (U d defined as D_{60}/D_{io}).

To calculate the U_c of a soil material, plot the gradation curve. Draw a horizontal line starting at the 60% passing point on the left axis. At the intersect with the gradation curve draw a vertical line down to obtain the grain size at which 60% is passing. Repeat this procedure for the 10% passing point. Dividing the size value at D_{io} into the size value at D_{60} results in the U_c.

U.S. Standard Sieves

3”   2” ¾”   3/8” 4 6 10   20 40 60 100   200



1000   100   1 0   1   0.1   0.01   .001

Grain diameter in millimeters

The suitability of a fill material can easily be assessed in the field using a 1-quart mason jar and *Cascade.* Put enough soil in the jar to cover the bottom. Add a very small amount of the *Cascade* (just a knife tip is fine) and add sufficient water to cover the soil. Occasionally swirl the jar gently. After 10 minutes, fill the jar with water and shake to uniformly distribute the soil material throughout the suspension. Let stand for about 10 minutes. A sample that remains cloudy probably has too many fines and its suitability should be questioned. If the water above the soil remains clear, the material is probably suitably as fill.

NOTE: Dissolved organic matter and iron sometimes also may cloud the water.

SOIL COLOR

Soil color is the most obvious and easily determined soil characteristic. Although it has little known direct influence on the functioning of the soil, color is one of the most easily determined soil properties and other more important soil characteristics can be inferred from soil color.

Coloring Agents in the Soil

- **Organic material** darkens the soil. As little as 2 to 5 percent can give the soil a dark brown to black color. It is a strong coloring agent and will mask all other color agents in the soil. Organic matter is typically associated with the surface layers and when it is observed below a mineral layer, it often indicates a disturbed site.
- **Iron** is the primary coloring agent in the subsoil. Iron bearing minerals are nearly universal in all New England soils. The bright orange-brown colors associated with upland soils is the result of iron oxide stains coating individual soil particles.
- **Manganese** is common in some New England soils and gives the soil a very dark, black or purplish black color.

In absence of color coatings on soil particles, soils are the color of the mineral grains which is often a grayish color due to the preponderance of quartz and feldspar minerals.

Munsell Color System
Soil colors are most conveniently measured by comparison with a color chart. The soil color charts consist of many different colored chips, systematically arranged according to their Munsell color notations.

Hue refers to the dominant spectral wavelength of light (red, yellow, green, blue, etc.). The symbol for hue is the letter abbreviation of the color preceded by a number from 0 to 10. With the YR (yellow red) range, the hue becomes more yellow and less red as the number increases. The notation for hue in the *Munsell Soil Color Charts is* located at the top right corner of each individual color chart page. One hue is represented on each page. The *EarthColors* book gives the color notation directly under each color chip.

Value refers to the degree of lightness and darkness of a color in relation to the neutral gray scale. The notation for value consists of numbers from 0 (black) to 10 (white). In the *Munsell Soil Color Charts,* value is located along the left side of the color page and increases from bottom to top. Color chips in the *EarthColors* book are arranged in a similar fashion with the color notation written directly under each color chip.

Chroma is the relative purity or length of the hue. The notation for chroma consists of numbers beginning at 0 for neutral grays (no pigment added) and increasing at equal intervals to 8. In the *Munsell Soil Color Charts,* chroma is located along the bottom of the color page and increases from left to right.
Once a soil color determination is made, the proper notation of the color is the hue, followed by the value and chroma. Value is always written first followed by the chroma. An example of the correct notation of a soil color would be IOYR 5/6 (hue of l0YR, value of 5, chroma of 6). The dominant color in the soil is called the matrix color. If there are multiple color observable in the soil, the most dominant color is the matrix color, while the non-dominant colors are called mottles. When soil colors are the result of oxidation and reduction (redox) processes on account of soil wetness we refer to these as redoximorphic features. Not all mottles are redoximorphic features.

Field Method for Recording Soil Color
People's perception of color varies and it's not unusual for people to vary one color chip. The following conditions may affect the accuracy of the color determination.

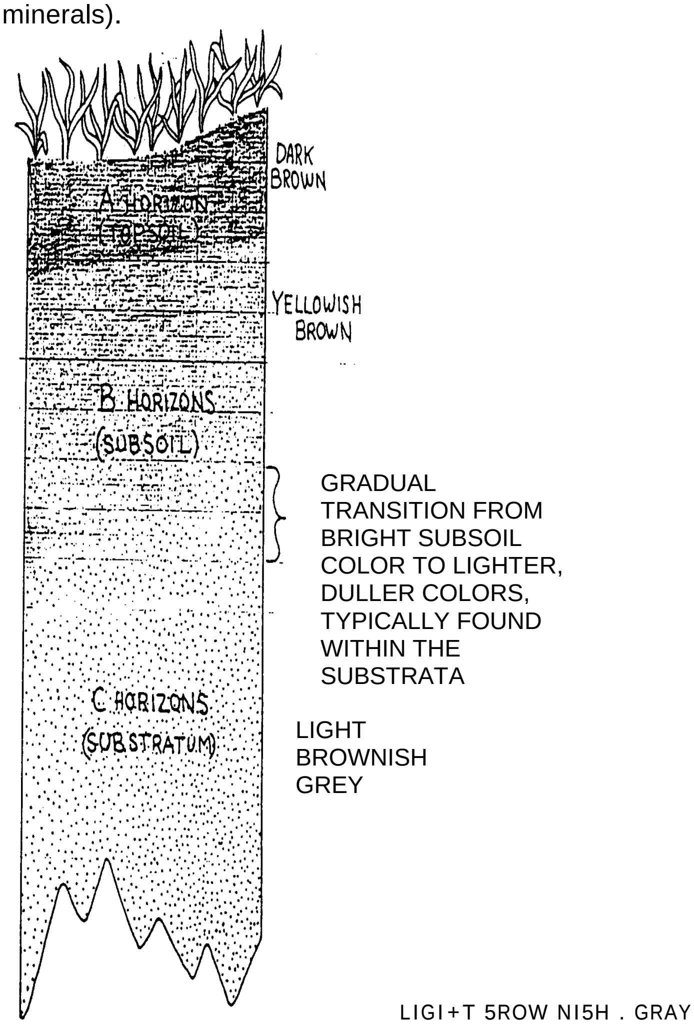
Moisture conditions: The moisture content (wet, moist, dry) of the soil has a bearing on the color of the soil. Moist color is the color most often recorded. It is typically the moisture condition of the soil when it is first removed from the pit. During periods that the soil is dry (summer and early fall, or during droughts) soil samples should be moistened with a gentle spray of water until the color is no longer affected by further additions of water. Be careful not to wet the soil too much (soil surface is glistening). Wet samples should be blotted with a paper towel.

Light conditions: Soil colors should be recorded under full light conditions. Interior lights generally do not provide a full spectrum light source, hence should not be used when determining soil color. Soil colors are recorded out-of-doors in indirect sunlight, typically sunlight from over your shoulder. When the sun is at a low angle either early morning, late afternoon or during the winter months; colors are difficult to read. *Note:* Please don't forget to remove your sunglasses. Weather conditions, particularly dark overcast days affect color readings and should noted on the soil log form.

Location in soil: Colors are typically recorded for the surface of a freshly-broken clod of soil. Do not mix your sample prior to the color determination. Multiple colors. If there is more than one color; determine which one is the matrix (dominant) color and which the redoximorphic features. Estimate the percentage of the various redoximorphic features as well as their Munsell color notation.

COLOR PATTERNS IN THE SOIL

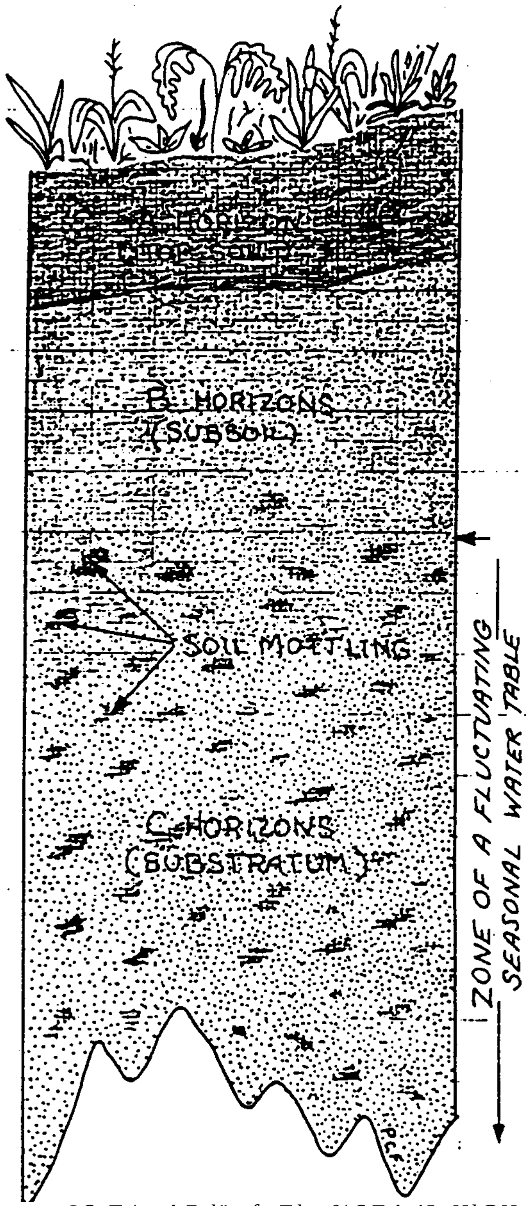
In a well-drained soil, the topsoil is typically a dark brown color underlain by a weathered yellowish brown to strong brown subsoil. The bright colors of the subsoil are the result of iron oxide stains coating the individual sand grains. With depth the color of the subsoil gradually fades to the substratum. The color of the substratum is dependent on the mineralogy of the individual soil particles and may range from a light brownish gray (soils high in quartz) to a dark grayish brown color (soils high in dark minerals).



SOIL MOTTLING (REDOXIMORPHIC FEATURES)

In a soil with a fluctuating water table, there are two contrasting chemical environments. When the water table is high and the soil is saturated, there is a reducing environment within the soil (lack of free oxygen). When the water table is low, the soil is well aerated and oxygen moves freely through the open pore spaces in the soil.

Within this zone of a fluctuating water table, iron, the main color agent in the subsoil, takes on two different forms. When the soil is saturated, iron is reduced (ferrous state) and becomes mobile in the soil migrating from one area to another. Gray areas develop in the soil where the iron has been depleted. When the water table recedes, in areas where the iron has migrated and concentrated, the iron is oxidized (ferric state) and is less mobile in the soil developing bright colors of yellow, orange and/or red. Within this zone of a fluctuating water table spots or blotches of color (redoximorphic features) are formed. Grey areas represent conditions where the iron has been reduced and flushed from the soil; whereas yellow, orange and/or red areas indicate iron accumulations. This blotchy pattern of both bright and dull colors is referred to as redoximorphic features and is interpreted by soil scientists as a zone in the soil with a fluctuating seasonal high water table.



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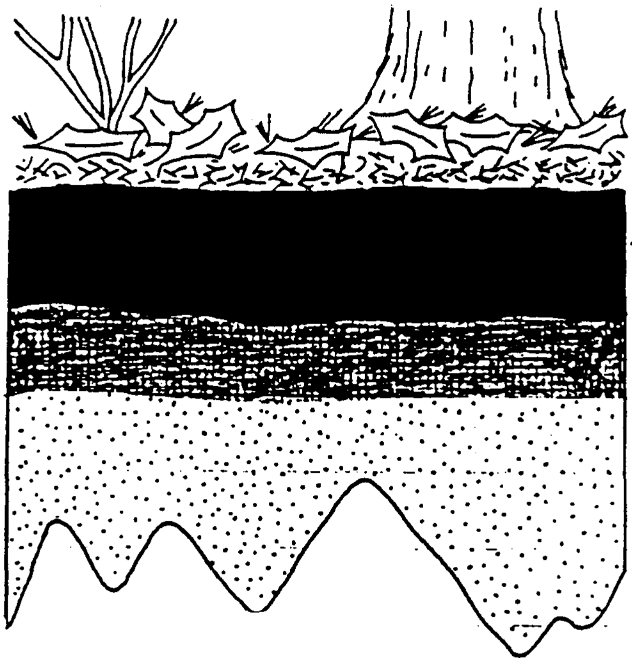
Soil developed within wetland areas where the soil is saturated to the surface for prolonged periods of time, there is typically a black organic rich topsoil (O, A or Ap horizon) underlain by a light grey subsoil (gleyed) that may or may not have mottles. In these soils the iron has been reduced and flushed out of the soil and the color is the result of the stripped quartz sand grains.



Potential Problem Areas When Interpreting Soil Mottling

- Sandy soils. Redoximorphic features are often faint and difficult to differentiate from the matrix.
- Relic mottles. Mottling that formed in a wet soil which has since been drained, persist for years and do not represent the present hydrology.
- Stratified deposits: changes in soil texture may momentarily interrupt wetting fronts as they move downward through the soil. This brief pause is not considered a perched water table but may produce bright streaks or blotches at the interface. These are often seen within gravel pits, high above the water table.
- Parent material: some soils develop in dark sediments and may mask soil mottling development.
- Soil chemistry: some soils have unique chemical properties that inhibit the development of redox-imorphic features. Soils developed within Triassic Red Sandstone sediments and soils that are immediately adjacent to brackish water are examples of soils which do not develop easily recognizable mottling.
- Recently-deposited material: mottles typically develop slowly, often taking lots of years to develop.

Describing Redoximorphic Features

A description of mottling requires a notation of the colors and of the color pattern. Colors noted using Munsell symbols for both the matrix and mottles. The color pattern may be described using abundance, size and contrast. For Title 5 purposes we will only describe the color of the redoximorphic features and their abundance.

- • **Abundance**: For Title 5 purposes a numerical estimate of the abundance of the redoximorphic features is required. Soil scientists when making routine profile descriptions use the following terminology:

  - Few: features < 2 % of the surface (f)
  - Common: features 2 - 20% of surface (c)
  - Many: features > 20% of surface (m)

- **Size**:

Fine:	< 5 mm	(1)
Medium:	5 - 15 mm	(2)
Coarse:	> 15 mm	(3)

- **Contrast:**

Faint	Hue and chroma of matrix and mottles closely related	(f)
Distinct	Matrix and mottles vary 1 to 2 hues and several units in chroma and value	(d)
Prominent	Matrix and mottles vary several units in hue, value, and chroma	(p)

SOIL STRUCTURE

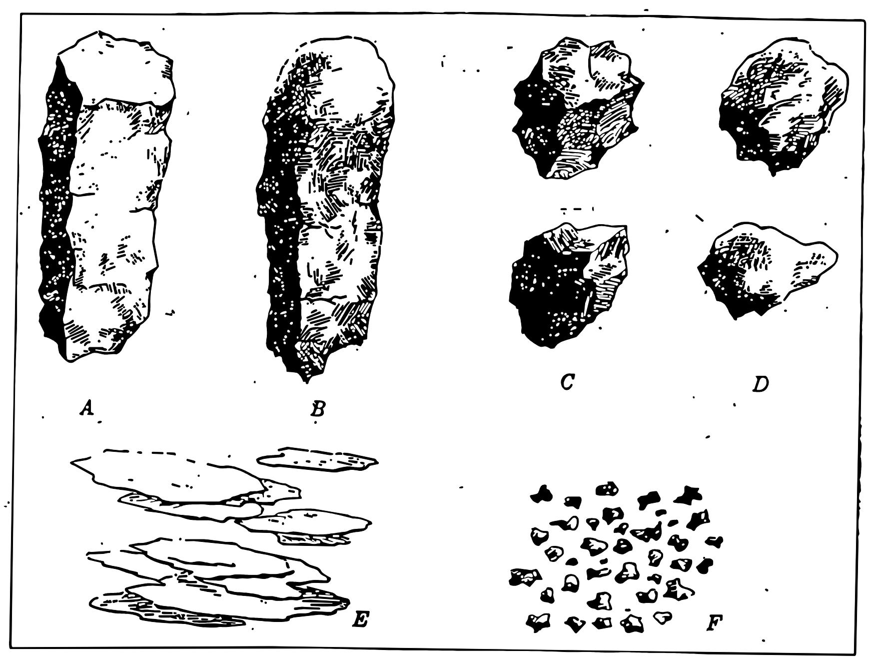
Soil structure refers to units composed of primary particles. The cohesion within these units is greater than the adhesion among units. As a consequence, under stress, the soil mass tends to rupture along predetermined planes or zones. These planes or zones, in turn, form the boundary. A structural unit that is the consequence of soil development is called a ped. The surfaces of peds persist through cycles of wetting and drying in place. Commonly, the surface of the ped and its interior differ as to co-position or organization, or both, because of soil development. Clods are structural units for which soil forming processes exert weak or no control on the boundaries. Some clods, adjacent to the surface of the body, exhibit some rearrangement of primary particles to a denser configuration through mechanical means (soil compaction). The same terms and criteria are used to describe peds and clods including shape, grade, and size.

Some soils lack structure and are referred to as structureless. In structureless layers or horizons, no units are observable in place or after the soil has been gently disturbed, such as by tapping a spade containing a slice of soil against a hard surface or dropping a large fragment on the ground. Structureless soil material may be either single grain or massive. Soil material of single grains lacks structure; in addition, it is loose. On rupture, more than 50 percent of the mass consists of discrete mineral particles. Some soils have simple structure, each unit being an entity without component smaller units. Others have compound structure, in which large units are composed of smaller units separated by persistent planes of weakness. In soils that have structure, the shape, size, and grade (distinctness) of the units are described. Field terminology for soil structure consists of separate sets of terms designating each of the three properties, which by combination form the names for structure.

- **Shape:** Several basic shapes of structural units are recognized in soils. Supplemental statements about the variations in shape of individual peds are needed in detailed description of some soils. The following terms and figure describe the basic shapes and related arrangements:

  - **Platy:** The units are flat and platelike. They are generally oriented horizontally. A special form, lenticular platy structure, is recognized for plates that are thickest in the middle and thin toward the edges.
  - **Prismatic:** The individual units are bounded by flat to rounded vertical faces. Units are distinctly longer vertically, and the faces are typically casts or molds of adjoining units. Vertices are angular or surrounded; the tops of the prisms are somewhat indistinct and normally flat.

- **Columnar:** The units are similar to prisms and are bounded by flat or slightly rounded vertical faces. The tops of columns, in contrast to those of prisms, are very distinct and normally rounded.
- **Blocky:** The units are blocklike or polyhedral. They are bounded by flat or slightly rounded surfaces that are casts of the faces of surrounding peds. Typically, blocky structural units are nearly equidimensional but grade to prisms and to plates. The structure is described as angular blocky if the faces intersect at relatively sharp angles; as subangular blocky if the faces are a mixture of rounded and plane faces, and the corners are mostly rounded.
- **Granular:** The units are approximately spherical or polyhedral and are bounded by curved or very irregular faces that are not casts of adjoining peds.



Different types of soil structure: A is prismatic, B is columnar, C is angular blocky, D is sub angular blocky, E is platy, and F represents granular structure.

- **Size**: Five size classes are employed: very fine, fine, medium, coarse, and very coarse. The size limits of the classes differ according to the shape of the units. The size limit classes are given in the following table. The size limits refer to the smallest dimension of plates, prisms, and columns. If the units are more than twice the size of "very coarse," the actual size is given. The size of structural units is not used for basic soil evaluation.

	Structure Shape			
Size Classes	Platy[1]	Prismatic	Blocky	Granular
	mm	mm	mm	Mm
Very fine	< 1	< 10	< 5	< 1

Fine	1-2	10- 20	5-10	1-2
Medium	2-5	20- 50	10-20	5-10
Coarse	5-10	50-100	20-50	5-10
Very coarse	> 10	> 100	>50	> 10

In describing plates, "thin" is used instead of "fine" and "thick" instead of "coarse."

- **Grade. Grade describes the distinctness of units.** Criteria are the ease of separation into discrete units and the proportion of units that hold together when the soil is handled. Three classes are used:

  Weak. The units are barely observable in place. When gently disturbed, the soil material parts into a mixture of whole and broken units and much material that exhibits no planes of weakness. Faces that indicate persistence through wet-dry-wet cycles are evident if the soil is handled carefully. Distinguishing structurelessness from weak structure is sometimes difficult. Weakly expressed structural units in virtually all soil materials have surfaces that differ in some way from the interiors.

  Moderate. The units are well formed and evident in undisturbed soil. When disturbed, the soil material parts into a mixture of mostly whole units, some broken units, and material that is not in units. Peds part from adjoining peds to reveal nearly entire faces that have properties distinct from those of fractured surfaces.

  Strong. The units are distinct in' undisturbed soil. They separate cleanly when the soil is disturbed. When removed, the soil material separates mainly into whole units. Peds have distinctive surface properties.

The three terms for soil structure are combined in the order (1) grade, (2) size, (3) shape. "Strong fine granular structure" is used to describe a soil that separates almost entirely into discrete units that are loosely packed, roughly spherical, and mostly between 1 and 2 mm in diameter.

- **Compound Structure** Smaller structural units may be held together to form larger units. Grade, size, and shape are given for both and the relationship of one set to the other is indicated: "strong medium blocks within moderate coarse prisms," or "moderate coarse prismatic structure parting to strong medium blocky. "

SOIL CONSISTENCE

Soil consistence in the general sense refers to "attributes of soil material as expressed in degree of cohesion and adhesion or in resistance to deformation on rupture. " Consistence includes: (1) resistance of soil material to rupture, (2) resistance to penetration, (3) plasticity, toughness, and stickiness of puddled soil material, and (4) the manner in which the soil material behaves when subject to compression. A similar term, consistency, was used originally in soil engineering for a set of classes of resistance to penetration by thumb or thumbnail (test designation D 2488, ASTM, 1984). The term has been generalized to cover about the same concept as "consistence." Consistence is highly dependent on the soil-water state and the description has little meaning unless the water state class is specified or is implied by the test. The consistence is described either in the dry or the moist state. When making soil descriptions in humid regions the soil-moisture state should be the moist condition. Consistence includes stickiness, plasticity, and toughness.

The evaluate the soil consistence, a block like specimen, 25-30 mm on edge, is compressed between thumb and forefinger, between both hands, or between the foot and a non-resilient flat surface depending on the degree of resistance. If the specimen resists rupture by compression, a weight is dropped onto it from increasingly greater heights until rupture.

Unless specified otherwise, the soil-water state is assumed to be that indicated for the horizon or layer when described. Cementation is an exception. To test for cementation, a specimen is air dried and then submerged in water for at least 1 hour.

The following consistence (rupture resistance) classes for moist or wetter soils can be identified:

Class	Test Description
Loose	Specimen not obtainable.
Very friable	Fails under very slight force applied slowly between thumb and forefinger.
Friable	Fails under slight force applied slowly between thumb and forefinger.
Firm	Fails under moderate force applied slowly between thumb and forefinger.
Very firm	Fails under strong force applied slowly between thumb and forefinger.
Extremely firm	Cannot be failed between thumb and forefinger but can be failed between both hands or by placing on a non-resilient surface and applying a gentle force underfoot.
Slightly rigid	Cannot be failed in hands but can be underfoot by full body weight applied slowly.
Rigid	Cannot be failed underfoot by full body weight but can be by dropping a 3 kg weight 10 cm.
Very rigid	Cannot be failed by dropping a 3 kg weight 10 cm.